WHAT IS CLAIMED IS:

1. A control system that controls a position of a mass by applying a control force to said mass in accordance with a desired mass acceleration, said control system comprising:

a first input that receives a signal based on a desired position of said mass;

a second input that receives a feedback signal indicative of an actual position of said mass;

a comparator unit configured to determine a signal indicative of a difference between said desired mass position and said actual mass position;

a control unit configured to produce a signal indicative of said control force based on said difference between said desired mass position and said actual mass position;

an estimator unit configured to calculate an estimated relation between said control force and status information of said mass, said status information comprising an indication of at least one of a position of said mass, a velocity of said mass, and an acceleration of said mass; and

a third input that receives a feed-forward signal indicative of said desired mass acceleration,

wherein said control system determines said control force based on said estimated relation and said desired mass acceleration.

2. The control system of Claim 1, wherein said estimator unit calculates said estimated relation in accordance with a least-squares method.

3. The control system of Claim 2, wherein said control system is configured to remove an offset of said control force.

4. The control system of Claim 3, wherein further comprising a high-pass filter to remove said control force offset.

5. The control system of Claim 1, wherein said estimated relation comprises an estimated mass.

6. The control system of Claim 5, wherein said estimator unit calculates said estimated mass by:

$$\hat{m} = \frac{\sum_{i=1}^{n} \lambda^{n-i}(a_i \cdot f_i)}{\sum_{i=1}^{n} \lambda^{n-i}(a_i)^2}$$

where:

$\hat{m}$ = estimated mass

a_i (i = 1, 2, 3, 4, …, n) is an acceleration sample.

f_i (i = 1, 2, 3, 4, …, n) is a control force sample.

λ is a forgetting factor.

7. The control system of Claim 6, wherein said control system is configured to calculate at least one of an estimated velocity coefficient, an estimated jerk coefficient, and an estimated snap coefficient from said feedback position signal.

8. The control system of Claim 7, wherein said at least one of said estimated velocity coefficient, said estimated jerk coefficient, and said estimated snap coefficient are used to determine said control force.

9. The control system of Claim 1, wherein said estimated relation comprises estimated filter coefficients that characterize said mass acceleration and said control force.

10. The control system of Claim 9, further including a transfer function unit that characterizes said desired mass acceleration.

11. A lithographic apparatus comprising:

a radiation system for providing a beam of radiation;

a support structure for supporting a patterning device, said patterning device serving to pattern said beam of radiation according to a desired pattern;

a substrate holder for holding a substrate;

a projection system for projecting said patterned beam onto a target portion of said substrate;

a control system to control a position of a movable object associated with said lithographic apparatus by applying a control force to said movable object in accordance with a desired mass acceleration, said movable object comprising at least one of said support structure and said substrate holder, said control system comprising:

a first input that receives a signal based on a desired position of said movable object;

a second input that receives a feedback signal indicative of an actual position of said movable object;

a comparator unit configured to determine a signal indicative of a difference between said desired movable object position and said actual movable object position;

a control unit configured to produce a signal indicative of said control force based on said difference between said desired movable object position and said actual movable object position;

an estimator unit configured to calculate an estimated relation between said control force and status information of said movable object, said movable object status information comprising an indication of at least one of a position of said movable object, a velocity of said movable object, and an acceleration of said movable object; and

a third input that receives a feed-forward signal indicative of said desired movable object acceleration,

wherein said control system determines said control force based on said estimated relation and said desired movable object acceleration.

12. The lithographic apparatus of Claim 11, wherein said estimator unit calculates said estimated relation in accordance with a least-squares method.

13. The lithographic apparatus of Claim 12, wherein said control system is configured to remove an offset of said control force.

14. The lithographic apparatus of 13, wherein further comprising a high-pass filter to remove said control force offset.

15. The lithographic apparatus of 11, wherein said estimated relation comprises an estimated mass of said movable object.

16. The lithographic apparatus of 15, wherein said estimator unit calculates said estimated mass by:

$$\hat{m} = \frac{\sum_{i=1}^{n} \lambda^{n-i}(a_i \cdot f_i)}{\sum_{i=1}^{n} \lambda^{n-i}(a_i)^2}$$

where:

$\hat{m}$ = estimated mass

a_i (i = 1, 2, 3, 4, ..., n) is an acceleration sample.

f_i (i = 1, 2, 3, 4, ..., n) is a control force sample.

λ is a forgetting factor.

17. The lithographic apparatus of 16, wherein said control system is configured to calculate at least one of an estimated velocity coefficient, an estimated jerk coefficient, and an estimated snap coefficient from said feedback position signal.

18. The lithographic apparatus of 17, wherein said at least one of said estimated velocity coefficient, said estimated jerk coefficient, and said estimated snap coefficient are used to determine said control force.

19. The lithographic apparatus of Claim 11, wherein said estimated relation comprises estimated filter coefficients that characterize said mass acceleration of said movable object and said control force.

20. The lithographic apparatus of Claim 19, further including a transfer function unit that characterizes said desired mass acceleration of said movable object.

21. A method of controlling a position of a mass by applying a control force to said mass in accordance with a desired mass acceleration, said method comprising:

determining information indicative of a difference between a desired mass position and an actual mass position;

producing information indicative of said control force based on said difference between said desired mass position and said actual mass position;

obtaining status information of said mass indicative of at least one of said position of said mass, a velocity of said mass, and an acceleration of said mass;

calculating an estimated relation between said control force and said mass status information; and

determining said control force based on said estimated relation and said desired mass acceleration.

22. The method of Claim 21, wherein said estimated relation is calculated in accordance with a least-squares method.

23. The method of Claim 22, wherein said estimated relation comprises an estimated mass.

24. The method of Claim 23, wherein said estimated mass is calculated in accordance with:

$$\hat{m} = \frac{\sum_{i=1}^{n} \lambda^{n-i}(a_i \cdot f_i)}{\sum_{i=1}^{n} \lambda^{n-i}(a_i)^2}$$

where:

$\hat{m}$ = estimated mass

a_i ($i = 1, 2, 3, 4, \ldots, n$) is an acceleration sample.

f_i ($i = 1, 2, 3, 4, \ldots, n$) is a control force sample.

λ is a forgetting factor.

25. The method of Claim 21, further including removing an offset of said control force.

26. The method of Claim 21, further including calculating at least one of an estimated velocity coefficient, an estimated jerk coefficient, and an estimated snap coefficient from said feedback position signal.

27. The method of Claim 21, wherein said estimated relation comprises calculating estimated filter coefficients that characterize said mass acceleration and said control force.

28. The method of Claim 27, further including characterizing said desired mass acceleration based on a corresponding transfer function.

29. A device manufacturing method comprising:

providing a substrate that is at least partially covered by a layer of radiation-sensitive material, said substrate being held by a substrate holder;

providing a beam of radiation;

configuring said beam of radiation with a desired pattern along its cross-section, said desired pattern provided by a patterning device supported by a support structure;

projecting said patterned beam of radiation onto a target portion of said layer of radiation-sensitive material; and

controlling a position of at least one of said substrate holder and said support structure by applying a control force to said at least one of said substrate holder and said support structure in accordance with a desired acceleration, wherein said position control comprises:

determining information indicative of a difference between a desired position of said at least one of said substrate holder and said support structure and an actual position of said at least one of said substrate holder and said support structure;

producing information indicative of said control force based on said difference between said desired position of said at least one of said substrate holder and said support structure and said actual position of said at least one of said substrate holder and said support structure;

obtaining status information of said at least one of said substrate holder and said support structure indicative of at least one of said position of said at least one of said substrate holder and said support structure, a velocity of said at least one of said substrate holder and said support structure, and an acceleration of said at least one of said substrate holder and said support structure;

calculating an estimated relation between said control force and said status information; and

determining said control force based on said estimated relation and said desired acceleration.

30. The device manufacturing method of Claim 29, wherein said estimated relation is calculated in accordance with a least-squares method.

31. The device manufacturing method of Claim 30, wherein said estimated relation comprises an estimated mass of said at least one of said substrate holder and said support structure.

32. The device manufacturing method of Claim 31, wherein said estimated mass is calculated in accordance with:

$$\hat{m} = \frac{\sum_{i=1}^{n} \lambda^{n-i}(a_i \cdot f_i)}{\sum_{i=1}^{n} \lambda^{n-i}(a_i)^2}$$

where:

$\hat{m}$ = estimated mass

a_i ($i = 1, 2, 3, 4, \ldots, n$) is an acceleration sample.

f_i ($i = 1, 2, 3, 4, \ldots, n$) is a control force sample.

λ is a forgetting factor.

33. The device manufacturing method of Claim 29, further including removing an offset of said control force.

34. The device manufacturing method of Claim 33, further including calculating at least one of an estimated velocity coefficient, an estimated jerk coefficient, and an estimated snap coefficient from said feedback position signal.

35. The device manufacturing method of Claim 29, wherein said estimated relation comprises calculating estimated filter coefficients that characterize said desired acceleration and said control force.

36. The device manufacturing method of Claim 35, further including characterizing said desired acceleration based on a corresponding transfer function.